Interpreting Arterial Blood Gases

Introduction

- Blood gas analysis yields important information about arterial oxygenation and acid-base balance.
- Yet for many people, interpreting ABG results is like solving a complex puzzle. In most cases, the difficulty stems from trying to make sense of all the measurements at once. If you consider the values that represent oxygenation and those that indicate acid-base balance separately, making sense of an ABG report will not be a daunting task.

PaO2 and SaO2: Taking a look at arterial oxygenation

- PaO2 and SaO2 provides information about the pts arterial oxygen supply.
- PaO2 = partial pressure of oxygen dissolved in arterial blood. (normal ranges are from 80 to 100 mm Hg).
- SaO2 = saturation of hemoglobin (normal ranges are 95% or better)

PaO2 and SaO2 Cont.

- PaO2 or SaO2 below normal often calls for immediate action.
- Keep in mind, that lower oxygen levels are expected at high altitudes, older people, and those with COPD.
- In these cases you will compare current findings with the pt's baseline ABGs.

pH and the key role of H+ ions

- H+ concentration and pH are inversely related. (Higher the H+=lower pH, Lower the H+=higher the pH)
- Normal pH of arterial blood is 7.35-7.45
- Changes in pH affect critical body functions
- Enzyme systems require a specific pH for proper function. (Acidosis, decreases the force of cardiac contractions, reduces vascular response to catecholamines; Alkalosis, can interfere with tissue oxygenation

Reviewing the basics of acid-base balance

- Acids are continually released as normal waste products of cellular metabolism.
- Carbonic acid is eliminated by the lungs.
- The rest-fixed or metabolic acids-are excreted by the kidneys or buffered

Buffer systems offset an excess in (acid/base) in order to keep a normal pH

- A strong acid enters the bloodstream, HCO3- combine with H+ to form carbonic acid (H2CO3), it then brakes down into H20 & CO2 and is eliminated by the lungs.
- Strong base (OH-) enters the circulation, it combines with carbonic acid , it then brakes down into HCO3- & H2O, which are excreted by the kidneys.

Buffer systems offset an excess in (acid/base) in order to keep a normal pH

- The PaCO2 and HCO3- measurements on an ABG report reflect the status of the components of the bicarbonate-carbonic acid buffer system.

$PaCO_2$ and HCO_3^- look at respiration, metabolism

- $PaCO_2$= partial pressure of carbon dioxide in arterial blood.
- There is an equilibrium between carbon dioxide and carbonic acid in the bloodstream, changes in $PaCO_2$ parallels changes in carbonic acid levels.

PaCO2 and HCO3- look at respiration, metabolism

- PaCO2 Normal range is 35-45 mm Hg
- Hypoventilation =PaCO2 rises above 45 mm Hg and acid load increases, producing a respiratory acidosis.
- This can occur with COPD, head trauma, over sedation, anesthesia, drug OD, and neuromuscular diseases (Gillain-Barre syndrome or Myasthenia Gravis), pt on vent with tidal vol. Set to low.

PaCO2 and HCO3- look at respiration, metabolism

- Hyperventilation, increases the excretion of CO_2. ($PaCO_2$ falls below 35 mm Hg = acid load decreases, causing a resp. alkalosis).
- Bicarbonate (HCO_3^-) levels are controlled by the kidney. (Normal values range from 22 –26 mEq/L)

Metabolic acidosis

- Takes place when and increase in acid load uses up the bicarbonate available for buffering and HCO_3^- levels fall below 22 mEq/L.
- Conditions that increase acid load are diabetic ketoacidosis, lactic acidosis, and renal failure.
- Actual loss of HCO_3^- through severe diarrhea or drainage of pancreatic secretions also reduces buffering capacity and leads to acidosis.

Metabolic Alkalosis

- A loss of acid may increase the HCO_3^- supply to more than 26 mEq/L (caused by vomiting or nasogastric drainage removes acid-rich fluid from the upper GI tract)
- Other causes= prolonged diuretic therapy, steroid therapy, Cushing's Disease, and aldosteronism can also deplete K^+, Cl^-, and H^+ ion levels, resulting in metabolic alkalosis.

Putting the pieces together

- Step One: label the pH.
- A pH between 7.35-7.45 may be the result of compensation. At this point, to avoid missing compensation states, label any ph below 7.40 acidosis & any pH greater than 7.40 alkalosis. You will re-evaluate these labels at the end of the next step.

Putting the pieces together

- Step Two: Find the cause of the acid-base disturbance by evaluating the $PaCO_2$ and HCO_3^- in relation to the pH.
- If the pH is below 7.40 and the $PaCO_2$ is greater then 45 mm Hg = Resp. Acidosis
- If the pH is less then 7.40 and HCO_3^- is below 22 mEq/L = Metabolic acidosis

Putting the pieces together (step-2)

- If the pH is greater than 7.40, and the $PaCO_2$ is below 35 mm Hg= Resp. alkalosis.
- If the pH is greater than 7.40, and the HCO_3^- is above 26 mEq/L= Metabolic alkalosis.

Putting the pieces together (step-2)

- Now take a second look at the pH between 7.35-7.40, labeled acidosis in step one. If both the PaCO2 and HCO3- are normal, change the pH label to NORMAL.
- Now take a second look at the pH between 7.40-7.45, labeled alkalosis in step one. If the PaCO2 & HCO3- are normal, change the pH label to NORMAL.

Putting it together Step-3

- Check for compensation. The body tries to restore a normal pH by altering the buffer system component (HCO_3^- or $PaCO_2$) that is not involved in the imbalance. If compensation has occurred, this value will move in the same direction as the other components.

The Body and pH

- The brain is very sensitive to declines in pH. When metabolic changes cause the pH to fall, respiratory rate and depth increase to eliminate more CO2 and restore a balance.
- Likewise, the kidneys respond to a respiratory-induced drop in pH by absorbing more bicarbonate and excreting more hydrogen ions.

The Body and pH

- The respiratory compensation begins minutes to hours after a fall in pH.
- The kidneys take a few days to respond.

Case Study One

- 54 y/o suffered an acute anterior wall MI and is now in cardiogenic shock. ABG as listed above.
- pH = 7.27
- $PaCO_2$ = 38 mm Hg
- HCO_3^- = 14 mEq/L

Case Study Two

- 72 y/o with COPD, hospitalized with an upper resp. infection. ABGs as listed above.
- pH = 7.39
- $PaCO_2$ = 60 mm Hg
- HCO_3^- = 34 mEq/L

Case Study Three

- 20 y/o developed acute renal failure after aminoglycside therapy, ABGs as above.
- pH = 7.36
- PaCO2 = 30 mm Hg
- HCO3- = 16 mEq/L

Case Study Four

- 53 y/o, sustained major trauma in an MVC. She has an NG tube in place that’s drained 1,500 ml in the last 24 hrs, ABGs as listed above.
- pH = 7.53
- $PaCO_2$ = 42 mm Hg
- HCO_3^- = 34 mEq/L

These four cases are examples of simple acid-base abnormalities.

- Mixed or combined imbalances can also occur. In such cases, both metabolism and respiration play a role in causing the abnormal pH.
- Interpreting these requires a more complex approach. Suspect a mixed imbalance if ABG results don't fall into line with you use the three-step method of analysis.

More likely than not a simple imbalance is the cause and this easy approach to interpreting ABGs will help you identify it quickly and confidently.